An Annotated Bibliography on Active Databases (Short Version)

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http://www.informatik.hu-berlin.de/~dbis/index.html

1 Introduction

This is a bibliography on active databases and active database systems which reflects the various research activities in this field. We compiled this bibliography for our own use, but hopefully it might be useful to other people as well. All papers that appear in the following list, are generally accessible.

We do not claim that the bibliography is exhaustive and covers the complete range of literature that deals with activities. We decided to focus on central approaches, concepts, methods, and systems in the area of active databases. It does not contain entries in the area of "pure" real-time, object-oriented, temporal, and deductive databases. But we did include publications related to those approaches, as long as they discuss active databases.

We divided the material into various sections following our own personal perception of the field. The sections provide an overview on different projects in the area of active databases, followed by sections on relevant research topics. Each section contains a few remarks followed by a list of cross references into the annotated bibliography. Papers might appear in more than one section in case they discuss different topics relevant to different sections.

Additionally, when relevant we also included unpublished, but publicly available material. For those papers we included information how to obtain them from the authors or from the organizations where the were produced.

The beauty of our work is the individual annotation to almost all publications. Due to space limitations we are forced to leave out those annotations in the version published here. For a complete annotated bibliography we refer to the entry in our WWW server[1].

The effort to build up such a bibliography is an endless task. Since we believe it now provides a comprehensive overview on the existing literature in the field, we decided to publish it. However, we invite all readers to add remarks, corrections, updates, additions (including further annotations).

Part of this work was done while we were associated with the FORWISS Institute of the Technical University of Munich. We would like to thank our student, Markus Blaschka, who compiled many references during his master's thesis.

2 Active DB Projects

This subsection briefly names projects on active databases and their current state as published so far. We distinguish direct references to "original author" publications, and secondary literature, e.g. comparative papers.

2.1 ADAM

ADAM is an object-oriented DBMS project. A prototype is implemented in PROLOG. Active extensions to ADAM treat method invocations as events. ADAM includes an object-oriented framework for defining several rule execution models.
References: [AMC93], [CAM93], [DPG91], [DE92], [DJPAQ94],
Secondary: [PDW+93]

[1] http://www.informatik.hu-berlin.de/~dbis/publications/tech-reports/index.html

2.2 AIS

AIS (Active Information System) is an active extension on top of Oracle and was developed at the University of Oldenburg, Germany. A prototype is running, and several applications were built. This project is a toolbox rather than an integrated monolithic system. It provides tools for browsing, designing, editing, simulation, debugging production rules, and explanation of rule results.
References: [Beh94], [Jas94]
Secondary: -

2.3 Ariel

Ariel is a project of the Wright Research and Development Center and Write State University, later University of Florida. A prototype of Ariel is implemented on top of the EXODUS storage manager. Ariel focuses on extensions to relational DBMS towards production rules. Production rule processing, especially condition evaluation, has to be efficient. The Ariel publications also discuss suitable data structures and indexes.
References: [Han89], [HB91], [Han92b], [Han92a]
Secondary: [CHS92], [HW93], [PDW+93], [VK93]

2.4 ATM

ATM (Activity/Transaction Model) is an activity started at DIGITAL in 1990. Based on (and extending) the HiPAC execution model it provides a framework to specify complex dependencies among transactions. ATM uses ECA rules to specify complex and parallel workflows. It is an interesting application for active rules. The original HiPAC execution model is well suited for advanced transaction models. ATM is a theoretical model without implementation.
References: [DHL90], [DHL91]
Secondary: -

2.5 Cactis

Cactis was developed at the University of Colorado by Hudson and King. It is an extended, object-oriented DBMS, designed for CASE and VLSI design. It provides functionally described attributes, which are evaluated immediately, lazy or on demand. These mechanisms are not explicitly called triggers but the execution model of Cactis can be seen as an interesting variant of an active DBMS.
References: [HK87], [HK89]
Secondary: [VK93]

2.6 CPLEX

CPLEX is essentially a language for defining and manipulating a persistent shared object base. It was implemented at Harvard University. The data model and data language is based on the DAPLEX functional data model. CPLEX supports two classes of rules: consistency rules and automation rules. Consistency rules detect a violated consistency constraints and execute a repairing action. If a set of proposed modifications to the database does not violate consistency, it may trigger automation rules. These rules are only fired if the proposed modifications have become valid.
References: [HC88]
Secondary: [ZB90]

2.7 ETM

ETM (Event Transition Monitor) is an extension to the DAMASKUS DBMS (FZI at the University of Karlsruhe, Germany). ETM was developed to maintain higher concepts of transactions for VLSI applications. Rules watch over constraints, and react by rollback or notification.
References: [Dan91a], [Dan91b], [DR91], [DR93], [KDM88]
Secondary: [Cha93]

2.8 HiPAC

HiPAC (High Performance ACtive database system) was funded by the Defense Advanced Research Projects Agency and the Rome Air Development Center. It was developed at CCA (Advanced Information Technology Division of Computer Corporation of America), and later migrated to Xerox Advanced Information Technology Center. The HiPAC prototype is an extension of the PROBE DBMS [CN90], but does not implement the full functionality of the HiPAC model.
References: [MD89], [RCBB89], [Cha89], [DBBC88], [DBM88], [HLM88]
Secondary: [Cha93], [Day88], [HW93], [PDW+93], [VK93] [ZB90]

2.9 Iris

Iris was developed at the Hewlett Packard Laboratories in Palo Alto. Although Iris does not claim to be active, its capability to evaluate functionally defined attributes propose many solutions that are useful in an active database context as well. Data updates are monitor in order to decide whether a rule has been activated. Evaluation of this rule can

be immediate, on demand and lazy. Some evaluations are part of the triggered transactions, some are decoupled and unsynchronized. Iris is the prototype basis of Hewlett Packard's object-oriented product *OpenOODB*.
References: [Ris89]
Secondary: -

2.10 Postgres

Postgres was developed at the University of California at Berkeley. Postgres is an append-only relational database, which includes object-oriented features. Triggers in Postgres were developed to implement views, inheritance mechanisms, and integrity constraints. A commercial version called ILLUSTRA, is available since 1994.
References: [RS87], [SHH87], [SHP88], [SHP89], [SJGP90], [SK91], [SR86], [SRH90]
Secondary: [Cha93], [CSS94], [HW93], [PDW+93], [VK93], [ZB90]

2.11 Ode

Ode was developed at AT&T Bell Laboratories. It is primarily an object-oriented DBMS with activity extensions. First publications emphasize constraint and trigger management. The Ode rule language is very powerful and includes facilities for temporal information. Finite automata are the formal basis for describing activities.
References: [AG89], [AMC93],[GJ91], [GJ92], [GJS92b], [GJS92a], [JQ92]
Secondary: [HW93]

2.12 REACH

REACH is a project at the Technische Hochschule Darmstadt, Germany. Influenced by HiPAC and DOM, it developed a core system named REACT, which implements a language comparable to Snoop (2.14). Two prototypes use O2 and ObjectStore as a platform in order to implement the object-oriented rule concept.
References: [BBKZ92], [BBKZ93]
Secondary: -

2.13 SAMOS

SAMOS is a project at the University of Zürich, Switzerland. While aiming at the HiPAC functionality, it has a rich language comparable to ODE (2.11). A prototype was based on GemStone OODB. [GD93a] and [GD94] mention a new prototype implementation on top of ObjectStore.
References: [GGD91], [GD92], [GD93a], [GD93b], [GD94],
Secondary: [PDW+93]

2.14 Sentinel

Sentinel is a project at the University of Florida, Database Systems Research and Development Center, Gainesville, Florida. It developed directly from results obtained in the HiPAC project. Several papers discuss prototypes on the basis of Zeitgeist and the *DARPA Open OODB* toolkit.
References: [CAM93], [CHS92], [CKAK93], [CKAK94], [CM91], [CM93], [CZ93], [CHS92]
Secondary: [AMC93]

2.15 Starburst

The Starburst rule extension was developed at IBM Almaden Research Center, San Jose, CA. It is an integral part of Starburst. The Starburst rule system is a production rule system tightly integrated into the transaction management. Among others starburst research addresses problems of rule interference, termination and scheduling of rule sets. The Starburst rule system is implemented. Another Starburst rule extension is Alert [SPAM91].
References: [ACL91], [AWH92], [Cha93], [CW91], [CW90], [CW92], [LLPS91], [Wid92a], [Wid92b], [Wid93], [WCL91], [WF89], [WF90]
Secondary: [HJ91], [HW93], [PDW+93], [SPAM91]

3 Special Issues

In the following we group the publications according to various issues in the context of active database systems.

3.1 Initial Reading

Recommended for initial reading in the field of active database systems or special topics are:
References: [Cha93], [Day88], [DG93], [HW93], [Mor83], [VK93]

3.2 Comparisons of Approaches

The following papers give overviews and comparisons of different active database systems and solutions:
References: [Cha93], [Day88], [DG93], [HJ91], [HW93], [PDW+93], [VK93], [ZB90]

3.3 Underlying Data Model

This subsection distinguishes the underlying data model, that is extended towards an active database system.

Relational

Extensions of relational datamodels are described in:
References: [GHJ93], [HJ91], [Smi92], [Beh94], [SKdM92], [Wid93], [WF90]

Object-Oriented

Extensions of object-oriented datamodels are desribed in:
References: [AMC93], [BBKZ92], [BBKZ93], [BOGM92], [BL92] [CHS92], [CM93], [DPG91], [DJPAQ94], [DM89], [EGB93], [HK87], [HK89], [Etz93], [GD92], [GD93a], [GD93b], [IK93], [KD93], [KLS92], [LW93], [NI93], [RS92], [SC93], [SVK93]

3.4 Deductive Approaches

Rule processing in deductive databases has a formal semantics. It is often restricted to first order logic and therefore is not well suited for active rule processing which requires a procedural approach. Nevertheless both deductive and active rule system approaches have many topics in common.
References: [ALUW93], [BJ93], [CHM94], [DR93], [DUHK92], [GHJ93], [HD93], [ODSD94], [SKdM92], [Urp92], [UO94], [Wid93], [Zan93]

3.5 Time Related Issues

Since many applications might be time critical, temporal information and timely rule execution is a major topic in active database systems.
References: [DBBC88], [CSS94], [DG93], [GD93a], [GD93b], [EGS93], [EGS94], [SC93], [SW92]

3.6 Execution Model

Activity management in databases is a fast developing and diverging research field. Until now there is no uniform formal model that widely accepted. Most models propose their own approach and describe the underlying semantics in terms of the execution model.

General Discussion

References: [WF90], [Wid92a]

Basic Event Detection

Mechanisms to detect basic events are described in:
References: [BJ93], [CM93], [GD93a], [HK89], [Ris89], [SHP88], [SJGP90],

Complex Event Detection

Mechanisms to detect complex events are described in:
References: [BJ93], [BL92], [Cha92], [CKAK94], [CM93], [GD93a], [GD94], [GHJ93], [GJS92a], [NTC92], [RCBB89], [SW92], [Wid92a]

Parameter Context Handling

The handling of parameters for basic events, and context information for complex events are described in:
References: [CM93]

Transactions

The following papers address rule execution in the presence of regular transactions within the DBMS:
References: [BBKZ92], [BBKZ93], [BOGM92], [CR90], [CR93], [DHL90], [DHL91], [DR93], [GD93c], [HLM88] [IK93], [SPAM91], [WF90], [ZB90]

Rule Analysis

In active database applications usually more than one rule is triggered at a time. Important aspects of rule execution are execution order, confluence and termination of rule execution.
References: [ACL91], [AWH92], [BCW93], [BW94a], [BW94b], [CW92] [ST94], [VS93]

Distributed Environment

Supporting active database functionality in a distributed environment poses additional challenges for maintaining and executing rules.
References: [BOGM92], [CW92]

3.7 Architecture

Architecture of active databases are addressed in:
References: [Cha92], [CZ93], [Jas94]

3.8 Implementation Issues

There are prototypes implemented, and the following papers discuss details of implementations:
References: [Car92], [CKAK93], [CN90], [Coh89],

[DM89], [GD93b], [GJS92a], [Han92b], [Han92a], [HB91], [HK87], [HK89], [KD93], [Mor83], [RCBB89], [WCL91]

3.9 Optimization

Optimization of rule execution spans from efficient event detection to efficient data condition evaluation to fast and non-redundant rule action execution.
References: [AVG92], [BGLM91], [BM93], [Cha89], [CHS92], [CN90], [CZ93], [DPG91], [FRS93], [HK89], [Smi92], [VK93], [UO94]

3.10 Performance, Benchmarks

Performance, cost models and benchmarks are discussed in:
References: [BM93], [GGD94], [ODSD94]

3.11 Tools

Definition of active rule sets are supported e.g. by browsers and debuggers.
References: [Beh94] [AWH92], [DJP93], [HJ91], [MSL93], [NTC92]

3.12 Applications

Since active database systems are intended to implement a greater portion of application semantics within the DBMS control, possible application areas are addressed in many papers. Since most active database models are not yet implemented or are in a prototype state, running real world applications are rare.

We distinguish general discussions of useful applications, requirement discussions and real application descriptions and experiences.

General Discussion

The following papers discuss possible application areas, and give an overview.
References: [BBKZ92], [CW90], [CW91], [DBM88], [SK92], [Wid94]

Requirements

The following papers discuss requirements for active database systems derived from certain application areas.
References: [CS94], [PDW$^+$93]

Concrete Application Descriptions

The following publications contain concrete application examples expressed in active rules.
References:

advanced transaction model	[GD93c]
query optimization	[PHH92]
graphical interface	[DJPAQ94]
workflow management	[BJ94]
cooperative problem solving	[CKNT92]
finance	[CS94]
views	[CW91], [SHH87], [SJGP90]
hospital information system	[DHL90], [DHL91]
traffic and stock control	[NI93]

Constraint and Integrity Management

Constraint management and integrity control are a classical application area for active databases.
References: [CFPT92], [CHM94], [CW90], [CW91], [Etz93], [Etz94], [FP93], [Ger94], [IK93], [JQ92], [LW93], [SHH87]

Application Experiences

Reports on real world applications are quite rare. Prototype experiments are often tested with toy examples only.
References: [Jas94]

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